Commissioning document of the CLAS12 RICH

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Abstract

This is an integration to the CLAS12 Commissioning Document describing the Commissioning procedure for the RICH detector.

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2.1 Quality Assurance

RICH Mechanic structure survey (EEL124)	
Description	Check of the relative position of the panels forming the RICH structure. The target points installed on the RICH mechanics will be used for the survey. The measured positions must match the ones measured during the assembly test performed at the company.
Special equipments	Laser tracker. Faro-arm.
Softwares	NA
Manpower and time needed	2 days
Information to be saved in database	NA

RICH Mirrors (EEL-121)	
Description	Check of the accuracy of the spherical mirror surface with spot size and Shack-Hartmann measurements. 1. Alignment of the Shack-Hartmann sensor axis. 2. Alignment of the mirror axis with respect to the Shack-Hartmann axis. 3. Alignment of the light source and photocamera for the spot size measurement. 4. Measure the spot size as a function of the distance from the mirror. 5. Wave-front measurement with the Shack-Hartmann sensor at the minimum spot size distance. 6. Shape of the surface with a CMM.
Special equipments	Two optical tables. Shack-Hartmann sensor. Point-like source with LED and optical fiber. CCD photocamera. Remotely controlled motors for the alignment of the system. Coordinate Measuring Machine (CMM)
Softwares	Linux software for the remote control of the motors and CCD. Root analysis software for the spot size measurements. Shack-Hartmann reconstruction software.
Manpower and time needed	About 2 days per mirror, based on previous experience
Status	First 4 mirrors tested in June
Information to be saved in database	Radius of the mirrors

RICH Mirror alignment (EEL124)	
Description	Verify the relative alignment of the RICH mirrors. Four mirror systems must be aligned: 1. the frontal planar panel. 2. the lateral planar panel. 3. the bottom planar panel. 4. the spherical panel. The relative alignment of the mirrors composing each panel will be checked first. Then the panel will be installed in the RICH and its alignment with respect to the others will be checked with optical methods. The position of the panel can be optimized by acting on the adjusting screws of the three attaching points on the RICH structure.
Special equipments	Laser tracker. Faro-arm.
Softwares	NA
Manpower and time needed	one week
Information to be saved in database	NA

RICH Aerogel: Catholic University (Washington)	
Description	Check of the optical quality of the aerogel tiles
Special equipments	Spectrophotometer
Manpower and time needed	About 1 day per 10 tiles, based on previous experience The work is performed at the Catholic University (Washington).
Status	10 tiles already tested
Information to be saved in database	Average transparency and refractive index of the tiles

RICH Aerogel (Ferrara)	
Description	Check of the optical quality of the aerogel on a subsample of tiles
Special equipments	Laser. CCD photocamera. Remotely controlled motors to scan the surface of the tile.
Manpower and time needed	About 1 day per tile, based on previous experience The work is performed in Ferrara.
Status	Started in October 2015
Information to be saved in database	NA

RICH Multi-Anode PMT	
Description	Characterization of the MAPMT
Special equipments	Pulsed laser source. Flash-ADC. Remote-controlled motors to scan the MAPMT entrance window.
Status	Completed
Results	Measurement of the Single-photon spectrum per each pixel of all the MAPMTs.
Information to be saved in database	Gain and single photon resolution of each channel at various H

Front-End Electronics	
Description	Verify electrical connections and power dissipation. Load the non volatile firmware image via JTAG connection Automatized diagnostic and verification of • volatile firmware image; • optical communication protocol; • preamplification gain, digital threshold, shaping parameters, masked OR configuration; • 64 inputs and digital outputs functionality; • binary outputs: electronic baseline, saturation, efficiency at 50 fC (1/3 photoelectron); • time resolution ($<$ 500 ps expected) and offsets; • charge response in range 50 fC - 1000 fC: linearity and hold-signal time offset.
Special equipments	Diagnostic board (custom). Injection Board (custom). Pulse generator. Computer with PCIe optical bridge.
Status	The task has been completed on the FPGA boards at JLab, and on the pre-production Adapter and Asics boards at Ferrara.
Manpower and time needed	2 person, 8 weeks.
Results	Minor issues were found on the pre-production Adapter and Asics boards and modifications were implemented to fix them in the final production.
Information to be saved in database	Digital line parameters: electronic baseline, saturation, efficiency at 50 fC, time offset.

Photon Detector	
Description	Group MA-PMTs with similar gain and connect to electonic tiles. Equalize performance in the single-photoelectron regime.
Special equipments	Pulsed laser test-bench (JLab)
Manpower and time needed	2 persons, 2 months
Information to be saved in database	Typical LV and HV currents and voltages, pre-amplification gains, digital thresholds, single-photon-signal efficiencies and time-over-thresholds.

SSP and DAQ	
Description	Test communication protocol of the RICH FFE with SSP modules: clock and trigger distribution, readout and event building.
Manpower and time needed	1 person, 1 months
Software	RICH DAQ
Special equipments	NA
Dependencies from other systems	CLAS12 DAQ software
Information to be saved in database	NA

Slow Control	
Description	Test communication protocol of the RICH Slow Control with hardware elements: SSP for DAQ, cRio for gas-system, SY4527 for power supply.
Manpower and time needed	1 person, 2 weeks
Software	RICH Slow Control
Special equipments	NA
Dependencies from other systems	CLAS12 DAQ software
Information to be saved in database	NA

2.2 System Checkout

Checkout of Low Voltage System	
Description	Connect the detector to LV supply, verify cable map, switch on single or group of boads, check of current and voltage stability.
Manpower and time needed	2 persons, 2 week.
Software	CLAS12 slow control.
Computing resources	NA
Dependencies from other systems	Slow Control and Cooling System are required to turn on the full electronic panel
Information to be saved in database	LV translation table, LV typical currents and voltage settings (for reference).

Checkout of the High Voltage System	
Description	Connect the detector to HV supply, verify cable map, switch on single or group of boards, check of current and voltage stability, check out dark count rates as a function of HV.
Manpower and time needed	2 persons, 2 weeks.
Software	CLAS12 slow control.
Computing resources	NA
Dependencies from other systems	LV system is needed to allow for PMT monitoring via dark-count measurements
Information to be saved in database	HV translation table, typical current and voltage settings (for reference).

Checkout of the Slow Control	
Description	Test the RICH slow control for monitoring of FEE tiles via SSP, gas system via cRio and LV and HV via SY4527 power supply.
Manpower and time needed	1 person, 2 months
Software	RICH slow control
Computing resources	NA
Dependencies from other systems	CLAS12 EPICS slow control system
Information to be saved in database	NA

Checkout of the Gas Systems	
Description	1. Nitrogen lines: gas flow, humidity, leak tests. 2. Cooling air lines: gas flow, temperature, humidity, leak tests.
Manpower and time needed	1 person, two weeks
Software	RICH Slow Control
Computing resources	NA
Dependencies from other systems	RICH Slow Control is required to monitor the condition and system stability
Information to be saved in database	Typical flow, pressure, humidity and temperature data

Checkout of the Interlock System	
Description	Checkout and test of the interlocks between HV, LV, cooling, gas systems
Manpower and time needed	1 person, one weeks
Software	CLAS12 slow control and interlock logic
Computing resources	NA
Dependencies from other systems	RICH services (gas systems and power supplies) have to be checked out prior of interlock
Information to be saved in database	Minimum and maximum values for pressure, temperatures and flows allowed by the interlock

Checkout of the Front-End Electronics and DAQ	
Description	Verify ASIC and FPGA configuration, calibration, channel mapping, noise level. Test different DAQ and trigger configurations.
Manpower and time needed	2 person, 2 months
Software	RICH DAQ and slow control, calibration software
Computing resources	NA
Dependencies from other systems	RICH servives (cooling, power supply, slow control and interlock) should be checked out in advance
Information to be saved in database	Channel translation table, calibration data

Cosmic runs with the electronic panel	
Description	Check of the full electronic system. Data will be acquired in two modes with the electronic panel put in horizontal position, with the MAPMT entrance window up: 1. self-trigger mode to record the charge particle hits in the full active area; 2. external hodoscope trigger to record the Cherenkov rings produced on an aerogel tile.
Manpower and time needed	run in batch mode, two weeks.
Special equipment	A simple tracking system should be setup in mode 2 for determining the cosmic trajectories.
Software	RICH DQ and analysis software.
Computing resources	Access to batch computing farm.
Dependencies from other systems	Cooling system and interlocks must be on.
Information to be saved in database	Time offsets.

Cosmic Runs with the Assembled RICH	
Description	Check of the RICH response to cosmics. Data will be acquired with the RICH put in horizontal position on its transportation trolley, with the aerogel panel down. Cherenkov photons will be produced in the aerogel, then reflected back by the frontal mirror toward the photodetectors.
Manpower and time needed	run in batch mode, two weeks
Special equipment	A simple tracking system should be setup for determining the cosmic trajectories.
Software	RICH DQ and analysis software.
Computing resources	Access to batch computing farm.
Dependencies from other systems	Cooling system and interlocks must be on.
Information to be saved in database	Time offsets.

3 Commissioning Without Beam

3.1 Special Calibration Procedures

Pedestal Runs	
Description	Determine the baseline of the Front-End electronics
DAQ configuration and trigger	CLAS12 random or internal pulse generator trigger
Manpower and time needed	1 person, 2 hours
Software	RICH DAQ and calibration software
Computing resources	Onlinde PC-farm
Dependencies from other systems	RICH stand alone test
Information to be saved in database	Pedestals (minimum digital threshold allowable)

Dark Runs	
Description	Calibration of the Front-End electronics using thermal noise.
DAQ configuration and trigger	Self-trigger mode
Manpower and time needed	1 person, 1 hours
Software	RICH DAQ and calibration software
Computing resources	Onlinde PC-farm
Dependencies from other systems	RICH stand alone test
Information to be saved in database	Single photo-electron time-over-threshold

Charge Injection Runs	
Description	Calibration of the Front-End electronics using the internal charge injector
DAQ configuration and trigger	Internal pulse generator trigger
Manpower and time needed	1 person, 1 hours
Software	RICH DAQ and calibration software
Computing resources	Onlinde PC-farm
Dependencies from other systems	RICH stand alone test
Information to be saved in database	gain and threshold, single p.e. time-over-threshold

3.2 Calibration with Cosmic Rays

Cosmic Runs in Hall-B	
Description	Global check of the RICH with cosmics.
DAQ configuration and trigger	CLAS12 DAQ and trigger for cosmics.
Manpower and time needed	1 person, 2 weeks.
Software	CLAS12 analysis software.
Computing resources	Access to batch computing farm.
Dependencies from other systems	CLAS12 tracking system.
Information to be saved in database	NA

3.3 Commissioning With Beam

RICH detector reconstruction calibration	
Description	After initial system checkout, a series of runs with different conditions will be performed. 1. Runs at different beam current to study the noise level. 2. Runs with torus off to check the detector geometry. 3. Runs with different torus magnetic field, including reverse field, to study the performance of the detector.
DAQ configuration and trigger	CLAS12 electron trigger
Manpower and time needed	one day of CLAS12 data taking
Software for analysis of results	CLAS12 tracking and RICH reconstruction software
Computing resources	Access to batch computing farm
Dependencies from other systems	All the CLAS12 detector on
Information to be saved in database	Several tuning parameters for the RICH reconstruction (background level, tracking resolution, single photon resolution, etc.).

RICH detector PID in the direct light case	
Description	Study the Kaon/Pion and Kaon/Proton rejection powers in the case of direct detection of the Cherenkov photons. Production data taken with liquid hydrogen target. Narrow resonances will be used to verify the RICH PID, for example: 1. K_S for pions. 2. ϕ for kaons. 3. Λ for protons.
DAQ configuration and trigger	CLAS12 electron trigger
Manpower and time needed	few hours of CLAS12 data taking
Software for analysis of results	CLAS12 and RICH reconstruction and PID software
Computing resources	Access to batch computing farm
Dependencies from other systems	All the CLAS12 detector calibrated
Information to be saved in database	Kaon detection efficiency vs pion and proton contamination.

4 Contact Persons

RICH contac persons			
Name	Affiliation	email	Area of responsibility
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